Electrical Hazards

9/989

U.S. Department of Labor
Mine Safety and Health Administration
National Mine Health and Safety Academy

Safety Manual No. 9

Revised 1989

L 38.8/2:

READEX FICHE best copy available

Electrical Hazards

U.S. Department of Labor
Elizabeth Dole
Secretary

Mine Safety and Health Administration
David C. O'Neal
Deputy Assistant Secretary

Safety Manual No. 9

Revised 1989

PREFACE

This is one of a series of pamphlets prepared by the technical staff of the National Mine Health and Safety Academy to acquaint the reader with a specific area of mining. This pamphlet deals with electrical hazards associated with the use of electrical equipment in all mines. Other pamphlets available in this series are listed on the inside back cover. Each deals with a single topic and is designed for use by miners, students and others interested in mining. A list of references (bibliography) is included at the end for those interested in additional information on the topics discussed in this pamphlet.

TABLE OF CONTENTS

	Page
Introduction	1
Electrical Accidents	3
What is Electricity	5
Shock Hazards	11
Surface Electrical Hazards	14
Electrical Enclosures	16
Mills & Preparation Plants	18
High Voltage Cable	20
Trolley Systems	22
Trailing Cables	26
Circuit Protection	28
Cable Protection	33
Wires and Cables	37
Grounding	41
Guards	43
Batteries	45
Summary	48
Bibliography	49
Glossary of Terms	50

12
9
3

INTRODUCTION

Electricity is a pure form of energy. Most electrical energy produced in the United States is generated in power plants that burn coal as a source of fuel. The mining industry needs electricity to mine and process coal and other minerals. Mining equipment such as continuous miners, loaders, shuttle cars, drag lines, shovels and drills need electricity. It is used for the transportation of material on conveyors, electric railroads and track haulage. It is used in preparation plants to power equipment that cleans the mined material. Large quantities of electricity are used in mining, but this is only a small percentage of the total electrical energy generated.

While electricity is necessary in mining, there are hazards associated with its use which must be understood and avoided. The primary hazards are those created by electrical arcs, electrically generated heat, electrocution and explosions.

Table 1 - Electrical Accidents and Injuries, 1973

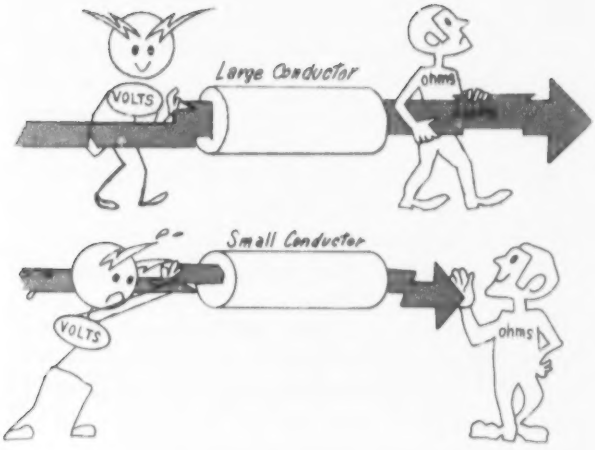
DESCRIPTION	NUMBER	PERCENT
Electrical Arcs	156	20.63
Electrical Burns	452	59.79
Burns (Heat)	72	9.52
Electrocution and Shock	53	7.01
Chemical burns	4	0.53
Contusion	4	0.53
Sprain or strain	6	0.79
Multiple injuries	8	1.06
Unclassified	1	0.14
	756	100.00

More than 96 percent of all electrical injuries were caused by (1) arcs resulting in burns; (2) electrically generated heat resulting in burns and scalds; and (3) electrocution and shock.

ELECTRICAL ACCIDENTS

Investigations of injuries related to using electricity in underground mines reveal that a large percentage of all electrical injuries are caused by (1) arcs resulting in burns; (2) electrically generated heat resulting in burns and scalds; and (3) electrocution and shock.

Accident statistics show that twice as many production workers are injured by electricity as are maintenance workers. Because of the hazards associated with electricity, Title 30, Code of Federal Regulations requires that any repair, installation or testing of electrical equipment be done by or under the direct supervision of a qualified electrician. In general, a qualified electrician is one who, through experience or training, has shown that he can perform electrical work efficiently and safely. Title 30 provides a more detailed explanation of the requirements to become a qualified electrician. However, every miner should understand electricity so he will be able to recognize and avoid electrical hazards.



Same amount of current, same voltage, a large conductor offers less resistance to the flow of current than a small conductor.

WHAT IS ELECTRICITY?

The terms associated with electricity are volts, amperes (current), and ohms (resistance). Voltage (V) or electromotive force is the pressure required to deliver the energy tc do the work; such as, turn a motor, light a bulb or produce heat. Measured in volts, it is comparable to water or hydraulic pressure.

Current, measured in amps, and designated by the letter "I", is the component that does the work. Like water, it is moved from one location to another by pressure (voltage).

Resistance, measured in ohms and designated by "R", restricts the flow of current. The resistance of an electrical circuit is determined by the physical size of the object through which current flows. The larger the cross-sectional area, the less the resistance; the smaller the cross-sectional area, the greater the resistance.

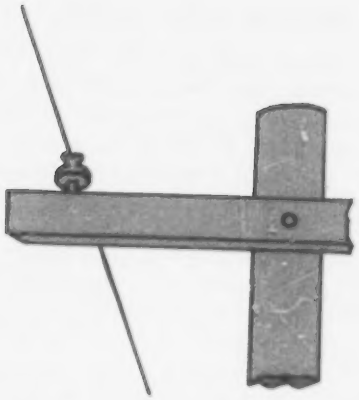
Voltage, amperage and resistance are all tied together by Ohm's Law.

Volts = Amps X Ohms (Ohm's Law)

(1) $V = I \times R$

(2) $R = V \div I = \frac{V}{I}$

(3) $I = V \div R = \frac{V}{R}$



Conductor: low resistance allows current flow.

Insulator: high resistance prevents a current flow, prevents shock hazard.

If any two of the values are known, the other one can be found by substitution. As an example:

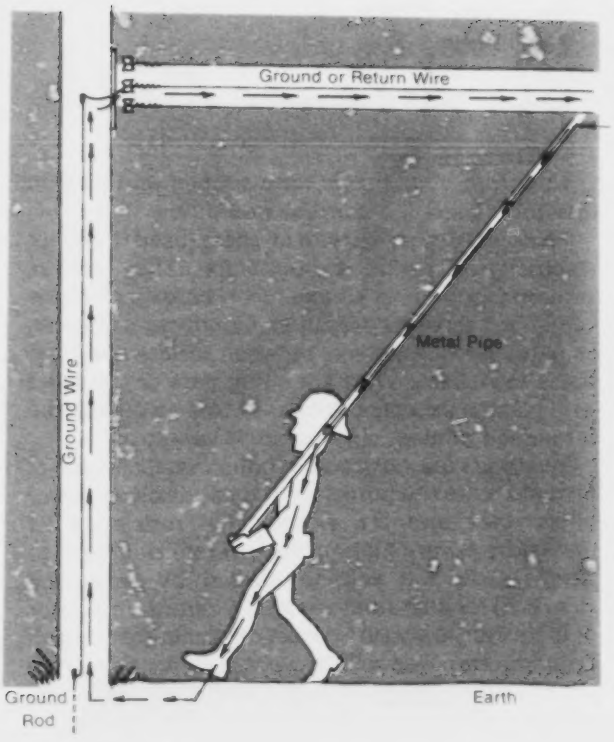
Volts = 120 Volts, a common household voltage
Resistance = 10 ohms
R = 10 ohms
I = ?
using formula (3) above:

$$I = \frac{V}{R} = \frac{120 \text{ volts}}{10 \text{ ohms}} = 12 \text{ amps}$$

Therefore, if 120 volts were applied to a 10 ohm resistor, 12 amps of current would flow.

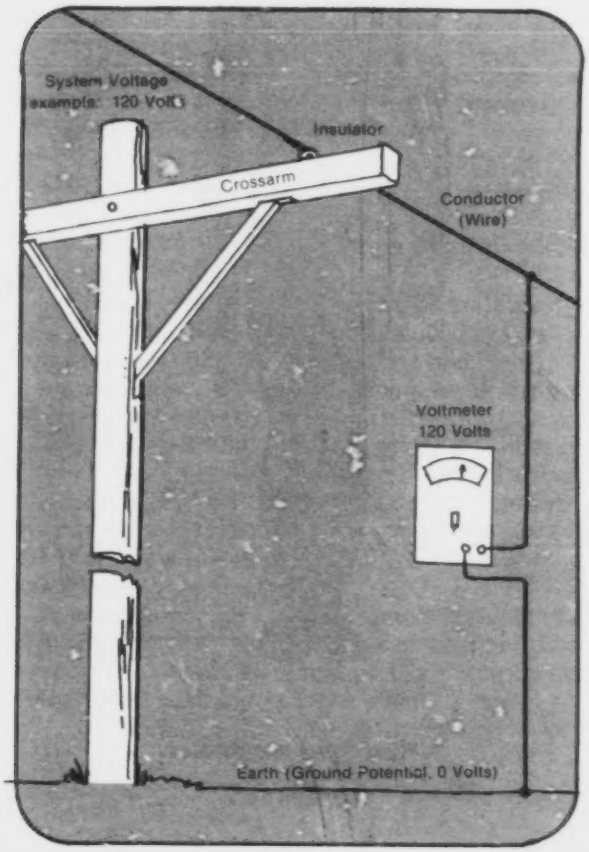
An object such as a wire or cable, used to deliver electricity is called a conductor. They are as common in houses as extension cords and cords with plugs serving appliances. Conductors are seen as wires between poles, between towers and from poles to houses. They are either bare or insulated with plastic, asbestos, rubber or treated paper. The resistance of most conductors is very low.

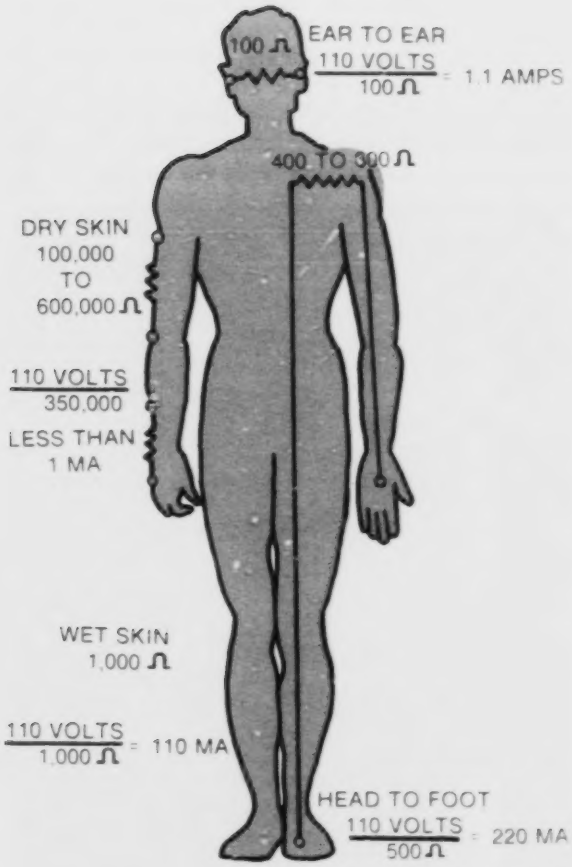
Insulators are not good conductors. Examples of insulators are the porcelain or glass discs on power poles that support wires. The resistance of insulators is very high. In fact, in referring back to Ohm's Law, the voltage divided by resistance (I = V/R) for an insulator is nearly zero. An insulator or insulation is also the rubber or plastic covering on a conductor. This will prevent a shock hazard as long as the insulation is rated for the voltage of the system and is kept free of cuts or other damage.



Through the accidental contact of the pipe to the wire, the body becomes a conductor between the ground and the source allowing lethal values of current to pass through the body. (See section on Shock Hazards)

A voltage difference, like a pressure difference, causes a current flow. The earth is considered as having zero voltage. A voltage difference would be present between a power line and the earth. A conductor placed between a power line and the earth would conduct current; the amount depending on the resistance of the conductor.





TYPICAL BODY RESISTANCE
&
CURRENT 1

SHOCK HAZARDS

The body is a conductor and also, like a conductor, has a resistance. Current will flow through the body when a voltage difference is present between two points on the body. (Example: hand on a power wire and standing on the ground).

The preceeding drawing indicates values of resistance in ohms (designated) that were determined by actual test. If a voltage existed between the hand and the foot, a resistor of 500 ohms (average) would be in the circuit. The voltage, 110 volts on the drawing, divided by 500 ohms, would give a current value of .22 amps or 220 milliamps. A milliamp (MA), is 1/1000th of an amp or, explained another way, it takes 1000 ma to equal 1 amp. A standard household 100-watt bulb requires less than 1 amp to light.

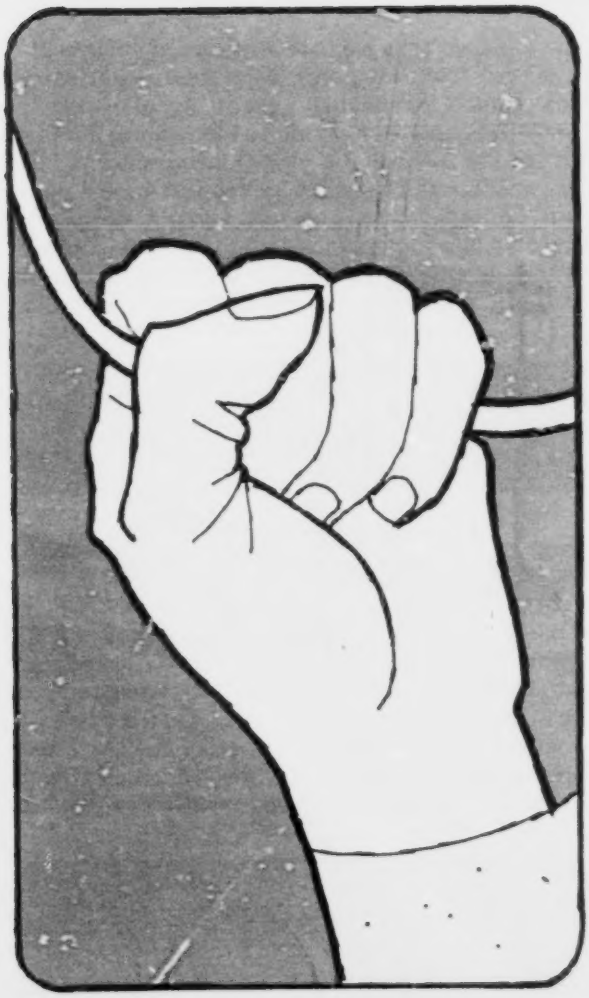
Notice the other resistance values on the drawing. Ohm's Law (I = V/R), is used to calculate values of current across different parts of the body.

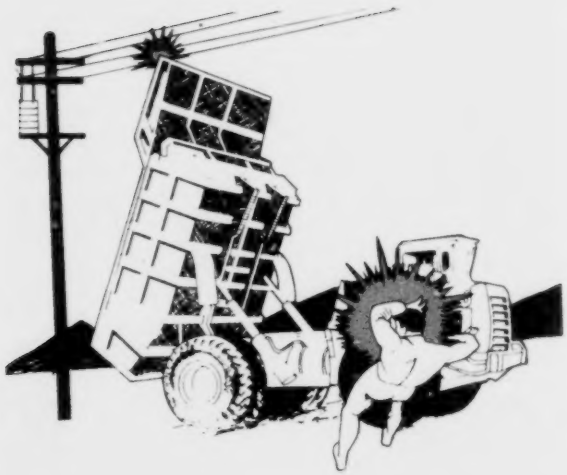
As calculated, a person touching an energized wire or circuit with any part of the body and standing on the ground would be subject to unsafe values of current. The most damaging current path is across the chest area. This path will pass current through the heart muscles disrupting the rhythm or beat of the heart. Low values of current flowing across the chest area could be fatal.

Investigations have shown that electrocutions involving as little as 27 volts can be fatal. Use caution around ALL electrical circuits. Table 2 gives values of current and possible effect.

Table 2 - Effects of 60-hz Current on an Average Human

CURRENT VALUES THROUGH BODY TRUNK		EFFECT
SAFE CURRENT VALUES	1 milliampere, or less	CAUSES NO SENSATION - NOT FELT. Is at threshold of perception.
	1 to 8 Milliamperes	Sensation of shock. Not painful. Individual can let go at will, as muscular control is not lost. (5MA is accepted as maximum harmless current intensity.)
UNSAFE CURRENT VALUES	8 to 15 Milliamperes	Painful shock. Individual can let go at will, as muscular control is not lost.
	15 to 20 Milliamperes	Painful shock. Muscular control of adjacent muscles lost. Cannot let go.
	20 to 50 Milliamperes	Painful. Severe muscular contractions. Breathing is difficult.
	100 to 200 Milliamperes	VENTRICULAR FIBRILLATION (A heart condition that results in death--no known remedy.) Disrupts or changes rhythm of the heart.
	200 & over Milliamperes	Severe burns. Severe muscular contractions so severe that chest muscles clamp heart and stop it during duration of shock. (This prevents Ventricular Fibrillation.)





Overhead high-voltage power lines create hazards for surface mine machine operators. Always check for power lines before raising beds or boom.

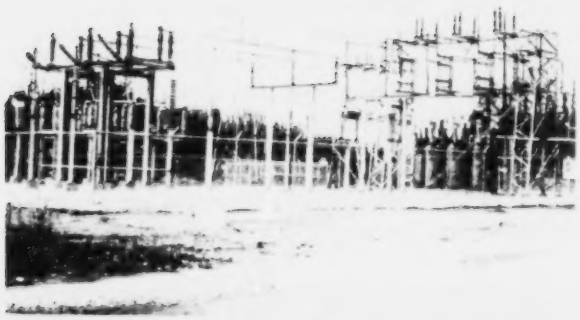
SURFACE ELECTRICAL HAZARDS

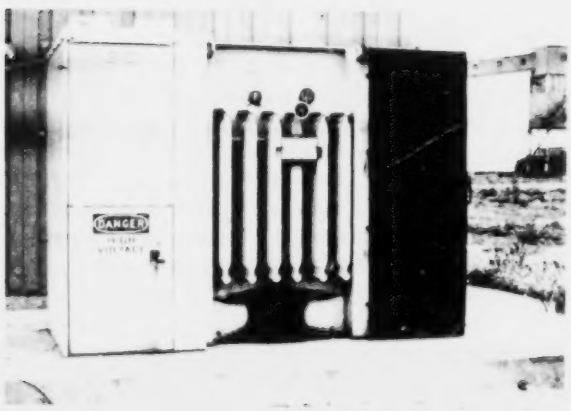
Electricity is delivered to mine sites by overhead power lines. These lines cross public highways and private haulage roads Trucks or cranes are required to maintain a minimum distance of 10 feet from any energized (power on) line. A truck bed or crane boom contacting a power line becomes a conductor. Anyone standing on the ground and touching equipment that is in contact with a power line would be subject to electrocution the same as if he had direct contact with the power line.

DO NOT TOUCH ANY EQUIPMENT OPERATING NEAR POWER LINES OR EXPOSED HIGH OR LOW VOLTAGE LINES

Storage and stockpile areas are common around all mining sites. Areas beneath overhead power lines are often used as storage areas. The initial ground clearance from the line may seem adequate, but repeated dumping and storage lowers the ground clearance. Distances from the ground to an energized conductor may be lowered until a person could touch the line with his hand. Minimum ground clearances for most power lines is set at 15 feet.

USE CAUTION WHEN CARRYING ANY LONG PIECES OF PIPE, STEEL OR WOOD IN THE VICINITY OF OVERHEAD LINES.



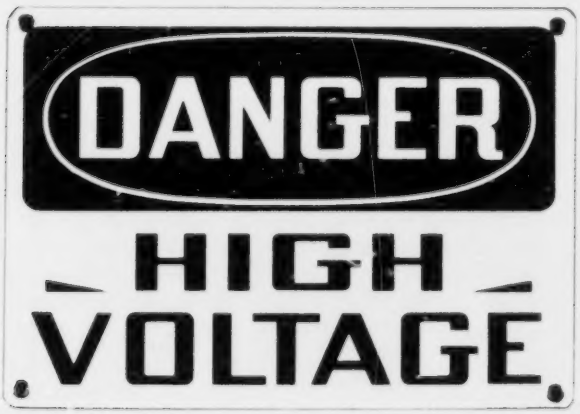


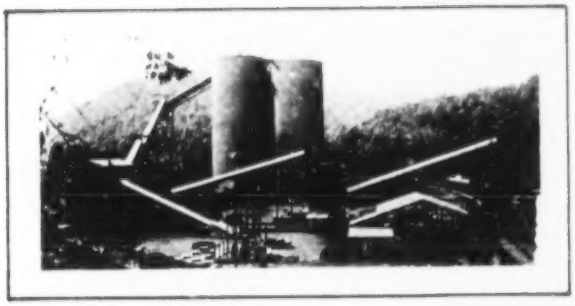
Stay out of electrical enclosures.

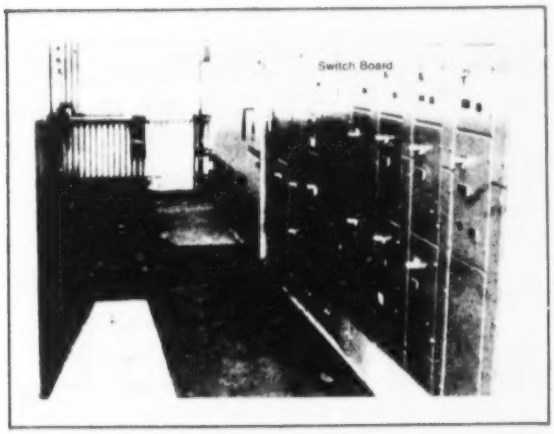
ELECTRICAL ENCLOSURES

Transformers located within substations are used to lower the voltage of overhead high voltage lines, usually 12,470 volts, to values that are safer for use within buildings, 120-240-480. Substations also contain switches, fuses or circuit breakers to protect cables that serve underground mines. Certain areas within substations contain exposed wires and connections. Therefore, they are usually protected by locked buildings, 6 foot high fences with locked gates, or installed with energized parts at least 8 feet above ground level. Electrical installations should also have signs warning of the dangerous high voltage and should only be entered by authorized trained personnel.

STAY OUT OF ELECTRICAL ENCLOSURES






Switch Board

MILLS AND PREPARATION PLANTS

Preparation plants contain many hazards. Electric motors, electrical switches, exposed moving parts and stumbling and slipping hazards are present in most areas of the plant. Poor lighting is also common in many older installations.

Rubber mats placed at electrical switches and controls are intended to prevent electrical shock. Mats act as insulators. Just like a high voltage conductor installed on an insulator to prevent grounding, a mat serves the same purpose for a worker preventing current flow through his body. Opening and closing switches or controls could cause a metallic enclosure to become energized to a high voltage. Workers standing on mats, grounded metal grids or dry wooden platforms would be protected.

DO NOT REMOVE RUBBER MATS FROM ELECTRICAL EQUIPMENT.

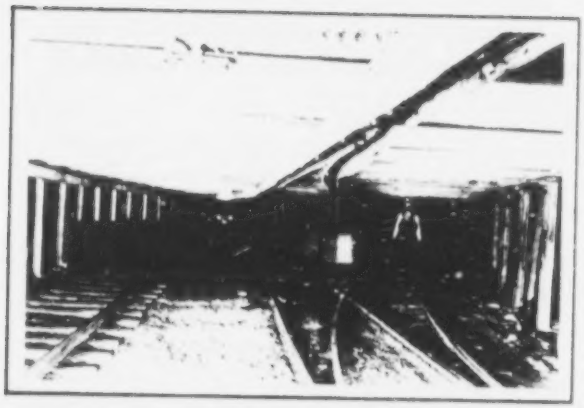
Unlighted areas could expose workers to unseen, stumbling hazards.

REPLACE ALL DEFECTIVE LIGHTS.
PICK UP ALL LOOSE OBJECTS IN WALK AREAS.
CLEAN UP ALL SPILLS.

Good housekeeping is necessary for safety and it is particularly important around electrical equipment.

Guards are installed to prevent a person from falling into moving machine parts and accidentally contacting exposed energized electrical connections.

KEEP GUARDS IN PLACE AT ALL TIMES.
WHEN THE MACHINE IS RUNNING, REPLACE COVERS ON ELECTRICAL SWITCHES.



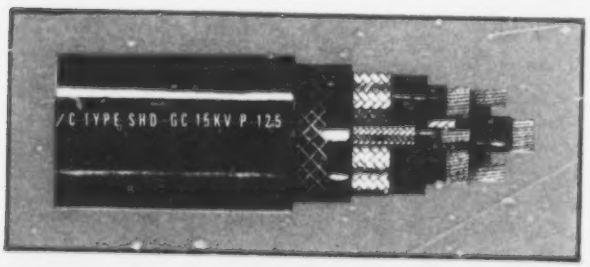
Do not touch energized high voltage cable. Guards should be installed where men or equipment pass regularly.

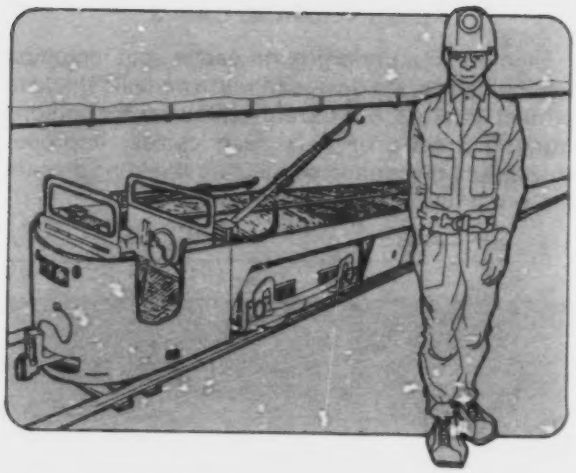
HIGH VOLTAGE CABLE

High voltage underground cables, not including trailing cables, are designed with a metallic shield to protect workers, but hazards still exist for persons working around or near such cables. Improper splices and disconnected metallic shielding present the worst hazards.

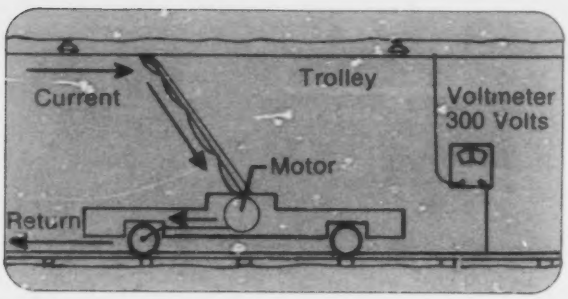
ENERGIZED HIGH VOLTAGE CABLE SHOULD NOT BE TOUCHED OR HANDLED EVEN WHEN WEARING APPROVED GLOVES AND SHOES.

High voltage cable is also required to be guarded where people work or pass regularly.





The bare trolley wire should be avoided. Walk and ride on the side opposite the wire and always cross under the wire where guarding is provided.



TROLLEY SYSTEMS

Trolley systems are the simplest type of electrical circuit in mining. There are two main conductors, the feed wire and the return. The trolley feed wire is installed on insulators. Tracks are the return conductors and are grounded. To operate a trolley-powered locomotive, the motor is connected with one wire to the tracks, through the wheels. Pumps and section equipment are connected in the same way but through more permanent electrical connections.

A voltage of 300 to 600 volts is present between the trolley wire and the track. Anyone working on an energized wire and standing on a rail without proper insulated gloves and shoes would be subject to electrocution.

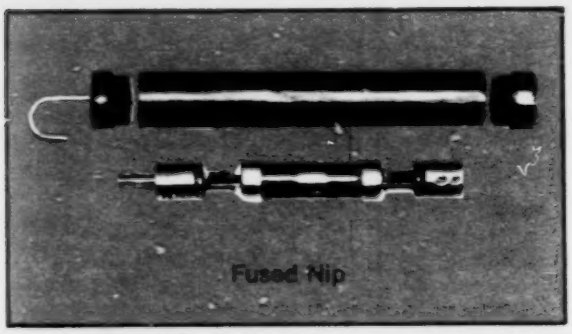
ONLY THOSE PEOPLE PROPERLY TRAINED TO PERFORM WORK OR REPAIRS ON ENERGIZED TROLLEY SYSTEMS ARE ALLOWED TO DO SO.

Trolley wires are required to be 6 1/2 feet above the mine floor or guarded where men are required to pass under or work nearby regularly. Guarding is also required where personnel board or disembark from personnel carriers, called man trip stations, and at the beginning and end of trolley wires. Trolley wire guards are usually yellow plastic or vinyl covers that enclose the bare, ungrounded wire. Guards are used to prevent electrocution due to accidental contact.

Step 1.
Touch back of nip to check for defective cable, defective machines or closed switches. If no arc, proceed with Step 2. If arc is present, properly tag and remove faulty circuit from service.

Step 2.
Over 60 percent of the electrical injuries are from arcs. When connecting or disconnecting power, be sure to wear rubber gloves, proper footwear and eye protection. Do not look directly at the wire.

Arcs in electrical circuits cause 80 percent of electrical injuries. A source of exposed arcing is trolley wires and connections to trolley wires. Cables attached directly to bare trolley wires are connected through "fuse nips". A fuse nip is a fiber-type cylinder with a fuse inside, a copper hook attached to one end and a power conductor to the other.



Fused Nip

Before proceeding with the following steps, examine the equipment and turn off all switches.

When connecting the fuse nip to a trolley wire, the nip will be at arm's length from the body. If switches on electrical equipment served by the fuse are left on, high surges of current and an arc, like a welding arc, will result. Looking directly at the nip could result in eye injury. Wear rubber gloves and protective shoes when making this connection. Turn your head slightly to the side and touch the back of the hook first to determine if there are any shorts or closed switches in the circuit. If no arc results, then place hook over the trolley wire.

Never pick up a cable without wearing proper protective equipment, rubber gloves with protectors and insulated shoes or rubber boots. Do not place an energized cable over the shoulder.

Hang or place trailing cables to prevent damage from moving equipment.

TRAILING CABLES

Some mobile underground and surface equipment are served by trailing cables. These cables are designed with a fire-proof, tough outer jacket to withstand the constant abuse of flexing, reeling and the exposure to sharp objects on the mine floor. Trailing cables were not designed to withstand being run over by mobile equipment.

NEVER HANDLE ENERGIZED TRAILING CABLE WITHOUT THE PROPER EQUIPMENT

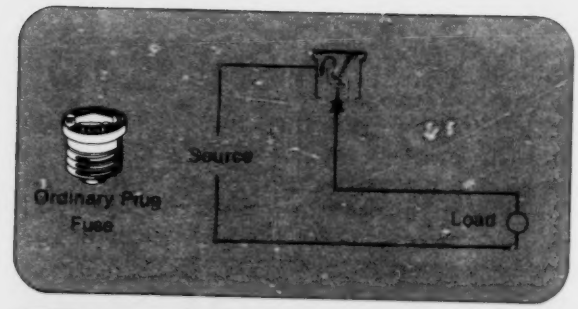
Proper equipment is considered to be rubber gloves with a leather protector and proper shoes or rubber boots free of any holes or cuts. The insulation of trailing cables is constantly being cut. These cuts sometimes expose the inner conductors. Anyone touching the cable at these points would be exposed to the system voltage.

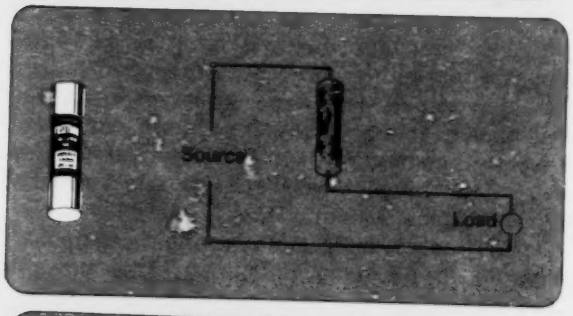
Trailing cables exposed to moving equipment are required to be hung or buried. This prevents possible damage to insulation.

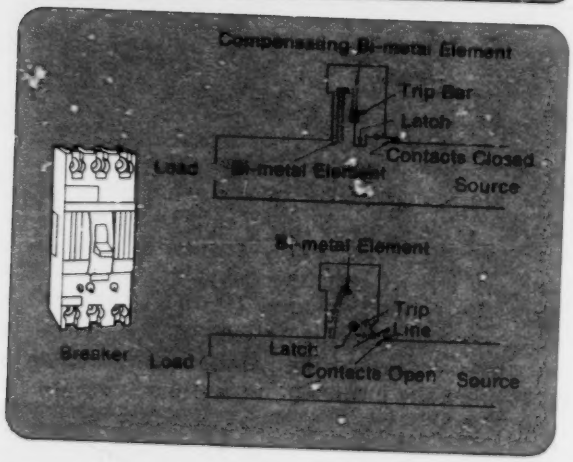
NEVER RUN OVER AN UNPROTECTED TRAILING CABLE.
DAMAGED CABLES SHOULD BE REPAIRED IMMEDIATELY.

Machines that have reels for trailing cable can be hazardous. These reels keep the trailing cable under tension at all times. Starting and stopping of the equipment causes a tension change on the trailing cable that can cause the cable to move or flex constantly. The closer one is to the machine, the more noticeable the movement. The tension could cause anyone unknowingly standing on the cable to be accidentally thrown to the ground.

ALWAYS USE CAUTION WHEN STANDING NEAR OR CROSSING TRAILING CABLES.


Source
Ordinary Plug
Fuse
Load


Source
Load


Compensating Bi-metal Element
Trip Bar
Latch
Contacts Closed
Load
Source
Bi-metal Element
Trip
Line
Latch
Breaker
Load
Contacts Open
Source

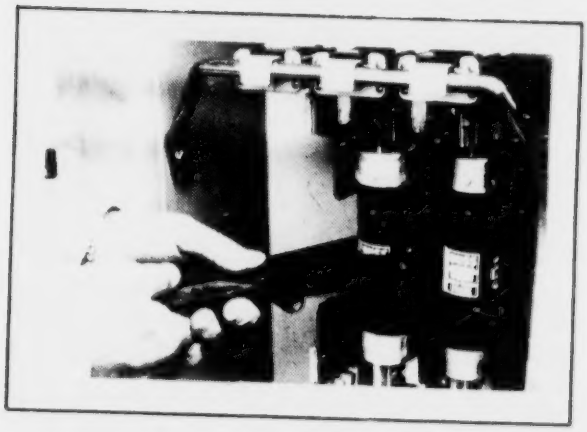
CIRCUIT PROTECTION

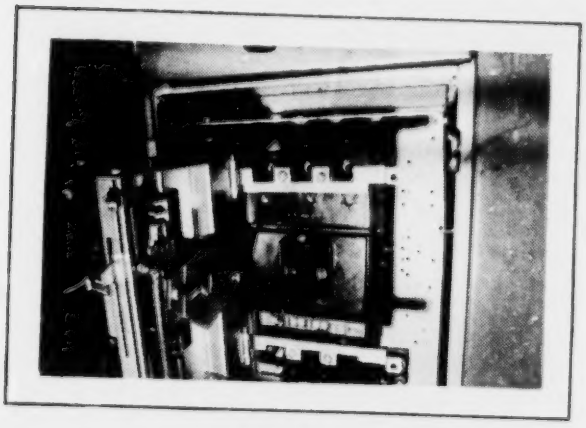
Current values exceeding the limits for which a wire was designed cause overheating. Overheating on a conductor softens wiring and damages wire insulation. Hot insulation will melt or crack and expose bare wires creating an electrocution or fire hazard. To prevent the overcurrent or overloading from occurring, a fuse or circuit breaker is installed in line with the circuit.

Fuses are the simplest form of a protective device. It inserts a predetermined wire size in line with the circuit wire. The wire element in the fuse is designed to melt and burn in two at a set current value. The current value is indicated on the outer covering of the fuse. Common values are 15 amp, 20 amp, or 30 amp for household fuses; and 100 amp, 200 amp, and higher values for industrial plants.

A fuse is designed to withstand the heating, that will occur due to overcurrent values, without damage to external parts. When a fuse burns in two, it opens the overloaded circuit.

The two common types of fuses are plug and cartridge. The plug fuse screws into a holder. A cartridge fuse is held by contacts. The operating principles of both are the same.



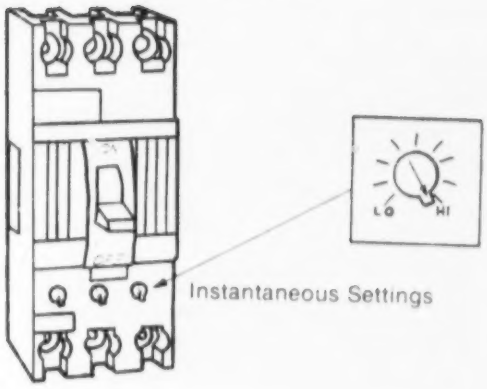


A circuit breaker is also common to home and industrial wiring protection. Like a fuse, a breaker has the value at which it will trip printed on the cover. Standard sizes found in home breaker boxes are 15 amp and 20 amp, which are for lighting and appliance circuits, and 100 amp or 200 amp for the main breakers. A circuit breaker is a mechanical device. A switch inside the breaker is tripped or opened by heat generated due to overloading the circuit. Circuit breakers can be reset and reused over and over.

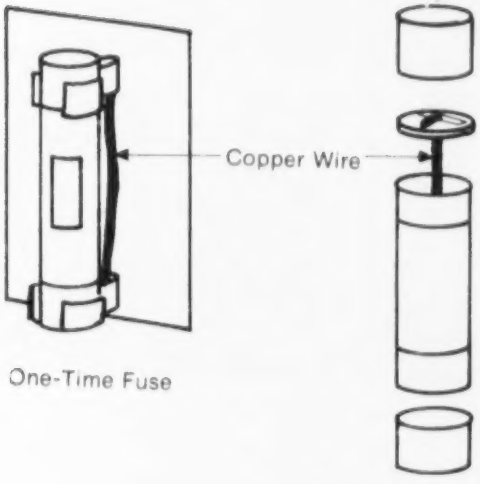
A blown fuse or a tripped circuit breaker could indicate an overloaded or defective circuit.

IF FUSES BLOW OR BREAKERS OPEN CONSTANTLY, CHECK FOR OVERLOADED OR DAMAGED WIRING AND EQUIPMENT.

Circuit Breaker



Bridged-out Fuses



One-Time Fuse

Renewable Fuse

CABLE PROTECTION

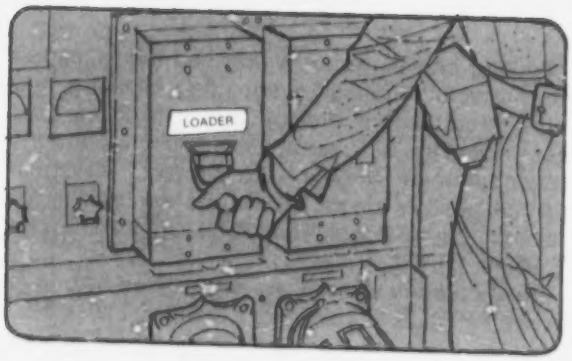
Trailing cables, motor wiring and feeder cables are protected against overloading, heating and short circuit conditions by circuit breakers and fuses. Breakers or fuses are sized according to the size conductor they are to protect. Maximum settings or sizes are set by law and are listed in the Code of Federal Regulations 30 CFR 75.601 through 75.601-3.

Instantaneous settings are determined by one or three small dials at bottom of a breaker. These dials are set by electricians and should not be changed by anyone except a qualified electrician.

Fuse protection is defeated by "wiring out" or "bridging out" a fuse. This is done by installing a piece of copper or aluminum wire beside of and in parallel with a fuse. This allows the fuse-wire combination to carry much more current than a fuse only and has been the source of many mine fires.

CHANGING CIRCUIT BREAKER SETTINGS OR "BRIDGING-OUT" FUSES IS A HAZARD AND A VIOLATION

Higher values of each will allow cable to heat and eventually burn, presenting a fire hazard to you and your fellow workers. Also, if a conductor contacts a ground wire the higher settings will not allow the protective equipment to perform their function. The result may be electrocution of machine operators and others.



1. Turn off breaker.

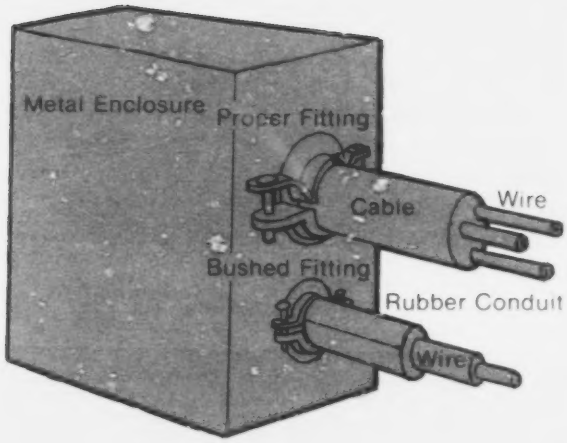
2. Open visual disconnects or pull plug.
3. Lock out and install danger tag.
4. Never connect or energize a circuit with a danger tag.

Before repair work can be performed on electrical equipment, the equipment has to be removed from service (turned off). Visual disconnects, disconnecting devices that allow a person to determine by observation that a circuit is "dead" or de-energized, are required on all electrical circuits. The disconnects may be blade switches or plug-receptacle combinations. To prevent a person from reconnecting the plug or closing the disconnects, a danger tag must be installed and the circuit locked out where possible. Only the person performing the work may disconnect and tag such circuits.

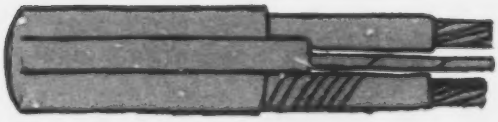
ONLY THAT PERSON OR A PERSON AUTHORIZED BY THE OPERATOR MAY REMOVE THE TAG.

WARNING!

Before attempting any cable repairs, make sure that the proper cable is disconnected and tagged out!


Metal Enclosure
Proper Fitting
Cable
Wire
Bushed Fitting
Rubber Conduit
Wire

Wire



Cable

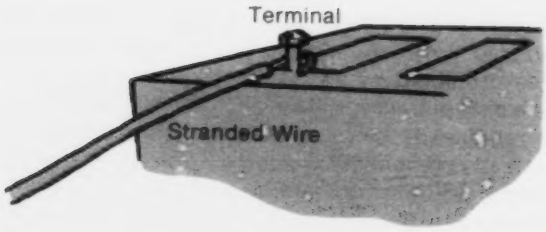
WIRES AND CABLES

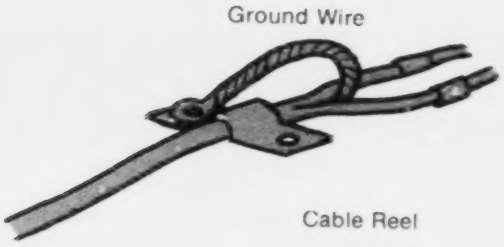
A wire is a single conductor with or without an insulated cover. A cable is two or more insulated wires protected by an insulated outer jacket. Any cable except trailing cables and high voltage cables are required to be installed on insulators and not touch any combustible material, such as roof, rib or timbers. Any worn or cut insulation, or short circuit condition in the electrical circuit could result in overheated cable and a possible fire.

CABLES ENTERING THE METAL ENCLOSURE OF ELECTRICAL EQUIPMENT SHALL BE PROVIDED WITH A PROPER FITTING

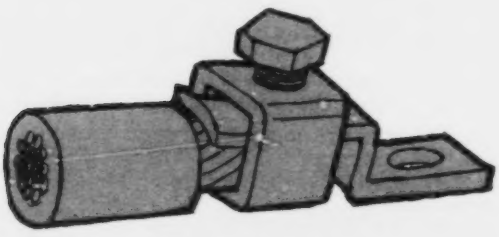
A wire entering this type enclosure shall have a bushed or insulated fitting. These fittings should be tight to prevent any strain on electrical connections within the enclosure.

Cables having cracked and/or brittle insulation should be checked thoroughly. These are signs of overheating caused by too small a cable for the required load. Trailing cables sometimes have the same heat fatigue signs. This is more often found on cable reel-type equipment and can be found on the last wrap of the reel. Heat fatigue can be attributed to a lack of air flow around the last wrap causing the heat build up.





Improper Connections
(wire placed under screw or bolt)



Proper Connection

STRANDED WIRE, WIRE WITH MANY SMALLER WIRES TWISTED TOGETHER, SHOULD NEVER BE TERMINATED WITHOUT A PROPER CONNECTOR

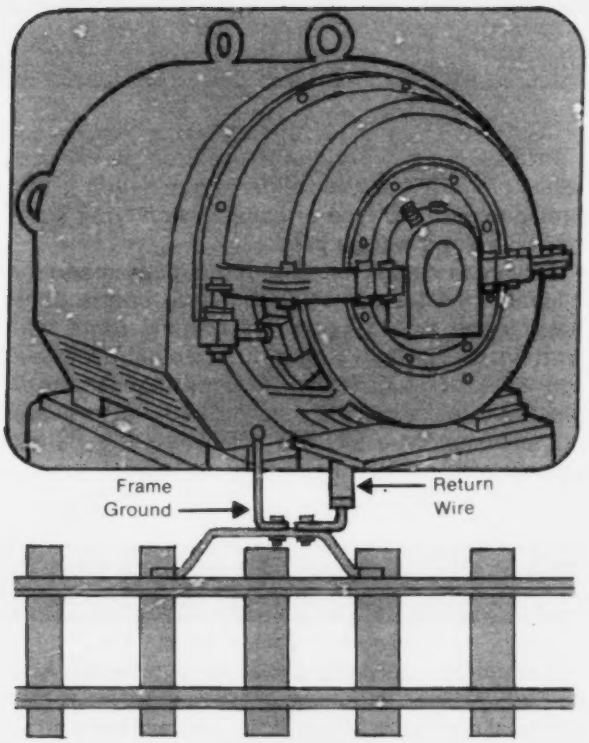
Proper connectors are bolted or screw-type terminals. When a special wire termination is not provided, a crimp type or compression type "stak-on" connector will be used.

Splices in cables are one of the more important maintenance jobs in mining. These connections have to be as strong as the original cable and conduct electricity without any heat build-up. Cable splice manufacturers have developed connectors to meet these requirements. The connectors are compression type sleeves, splice rings or bolted connectors.

TYING A KNOT (SQUARE KNOT OR ANY OTHER) IN A CABLE IS NOT ALLOWED.

Remember to always splice all ground wires. Also, the ground wire should have a little more slack than the phase or hot conductors to prevent extra strain on the ground wire.

After the mechanical joining has been completed, the cable has to be reinsulated to furnish the same degree of protection as before. This includes each phase or hot wire and the final outer jacket. Special splice kits for this purpose are manufactured for trailing cables and high voltage cables. When installing these splice kits, the manufacturer's directions shall be followed.



Under Separate Connections

The frame ground wire is the most important connection to be made in an electrical circuit. The frame ground wire protects workers from electrical shock due to failure of insulation.

GROUNDING

Grounding is one of the most important parts of any electrical circuit. A good ground prevents a voltage from existing on the metal frame of a piece of equipment for any long length of time. Ground wires establish a return path for grounded phase conductors to allow the fuse or circuit breaker to open the faulted circuit. A voltage that persists will present an electrocution hazard to workers.

If an electrical circuit has to be disconnected for any reason; disconnect the ground wire last.

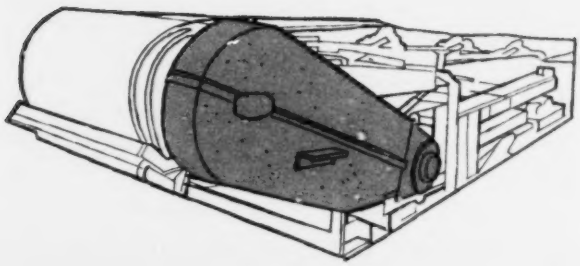
NEVER DISCONNECT THE GROUND WIRE FROM EQUIPMENT WHILE SUCH EQUIPMENT IS ENERGIZED.

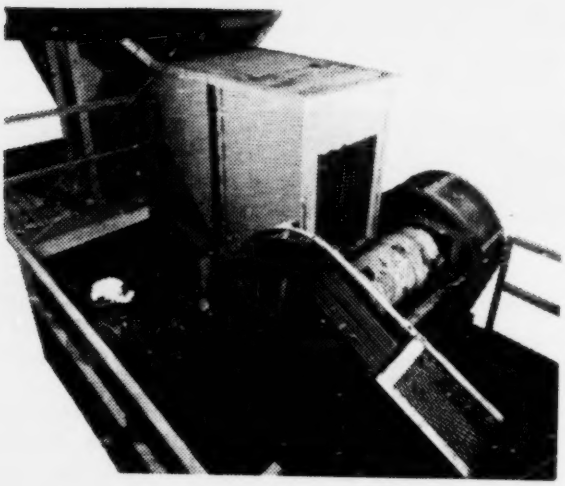
ANY METALLIC BOX OF AN ELECTRICAL ENCLOSURE CONTAINING ENERGIZED ELECTRICAL PARTS MUST BE GROUNDED.

Frame ground wires can be identified by green insulation, green with yellow stripe insulation, or a bare uninsulated wire. Report any disconnected or broken ground wires.

Tracks on a trolley system are the main ground for all equipment served from the trolley wire. Pumps, belt drives and section equipment served from trolley wires have a grounding wire connected directly to the track. The current-carrying return wire and the frame grounding wire are required to be connected under separate clamps at the track.

GUARDS





Mechanical moving parts of electrical equipment must be guarded to prevent workers from becoming entangled in the moving part.

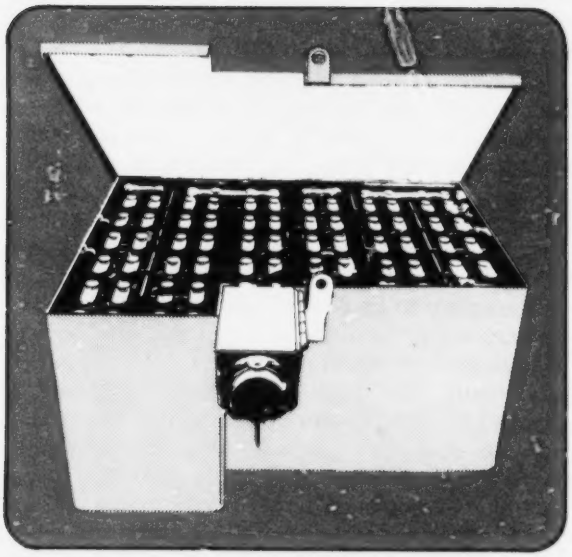
GUARDS

Exposed sprockets, belt drives, chain drives, and head and tail rollers offer special hazards. These objects all consist of a belt or chain being pulled over a roller or gear. An object caught between the gear or roller and chain or belt would be pulled into the device. Loose clothing, shovels, boards or arms are examples of such objects. Many fatal accidents have been attributed to this hazard.

Machines having exposed rotational parts are required to be guarded. A guard is designed to cover the exposed moving parts. Anyone who accidentally fell near the equipment would be protected from contacting the moving parts by the guard. The guard should also prevent a person from reaching around the guard and contacting the moving part.

Guards are to be kept in place at all times when the machine is running. If it becomes necessary to clean or perform maintenance work on the guarded equipment, the equipment shall be properly removed from service or disconnected. Remember the procedure for removing equipment from service? The switch shall be opened, the visual disconnect device or plug will be disconnected and the system locked out and tagged out, if possible. Only then can the cleaning and maintenance work begin.

NEVER REMOVE GUARDS FROM ENERGIZED MACHINES AND EQUIPMENT.
ALWAYS REPLACE GUARDS BEFORE RESTARTING EQUIPMENT.



Batteries are a possible electrocution source.

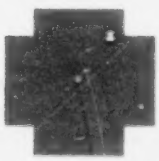
BATTERIES

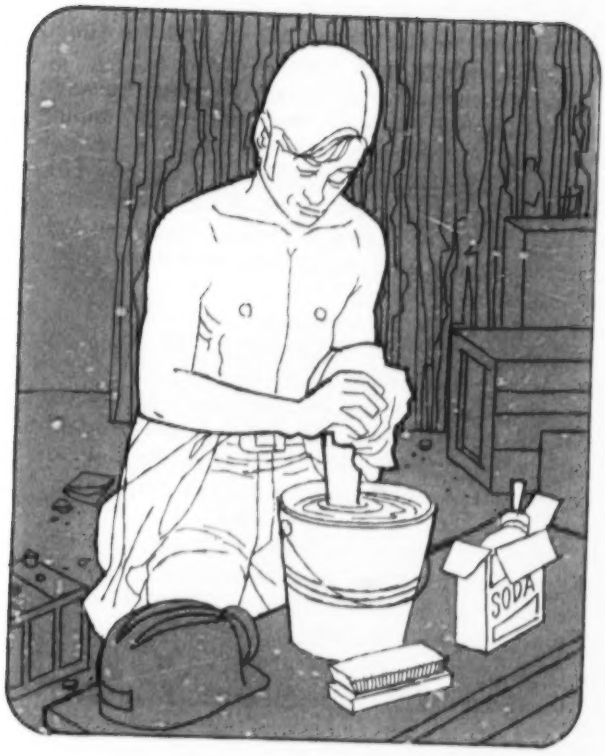
Many mines use battery-powered equipment. Batteries eliminate trailing cables and the added work required for their maintenance.

Physical size is the only basic difference between an automobile battery and the large mining batteries. Automobile batteries have a voltage output of 12 volts. Count the water filler caps on top of the battery. There are six. Each cap is one cell in the tray. Six cells complete the tray. Each cell adds two volts to the total output. (6 cells X 2 volts/cell = 12 volts.)

Check a large mining battery tray. The filler caps also represent one cell each. There are many cells connected together in series. Each cell also has a voltage output of two volts. As many cells as needed are connected in series to reach the desired voltage output to operate the electric motor on the equipment. A common tray voltage output is 300 volts.

A trolley system car have 300 volts between trolley wire and track. A large tray of batteries also has 300 volts output. There is no difference between the two in output voltage. The 300 volts are a possible electrocution hazard either from the trolley wire or battery tray.





Batteries are a source of electrical power and should be treated as a possible shock hazard. Batteries also present the possibility of explosion (hydrogen gas) and acid burns. Acid burns should be washed with ample amounts of H_2O or baking soda solution.

Acid and explosive gases are also hazards common to batteries. The liquid found in battery cells consist of a water-sulphuric acid mixture. This mixture will cause severe skin burns and eye damage if allowed to remain in contact with these areas. Plenty of clean water or a baking soda-water solution will dilute the acid.

The electrical energy used from a battery has to be restored frequently. An automobile uses an alternator to charge the car battery. Mining batteries are recharged by battery chargers. During the recharging cycle and use cycle, the chemical reaction produces hydrogen gas. Hydrogen gas can be very explosive. Charging stations and battery compartments can have explosive concentrations of hydrogen gas. Ventilation, to remove hydrogen gas, is important at charging stations and in battery trays.

To minimize fire hazards, the tops of batteries are kept clean. Cleaning removes grease and dirt from cells. This is accomplished by cleaning with the water-baking soda solution mentioned before.

PROPER MAINTENANCE OF BATTERIES INCLUDES CLEANING THEM.

SUMMARY

Electricity is necessary in mining. Anyone working around mining and mining equipment will constantly be exposed to electrical cables, wires, enclosures and motors. If systems are properly designed, installed and maintained, no hazard more than those at home will exist. Hazards exist when personnel attempt to alter or change the original jobs for which electrical circuits or equipment are designed.

Do not perform work on equipment unless you are qualified. Do not energize equipment or circuits until a complete examination has been performed showing that the equipment, or circuits will function safely. Fuses or circuit breaker sizes and settings should only be changed by a qualified person. Never touch an electrical conductor unless you are sure the circuit has been de-energized, opened, and properly tagged.

Remember:

1. You are your best safety guard.
2. Keep your resistance high.
3. Use your safety equipment.
4. Take action to protect yourself and your fellow workers.
5. If you do not understand, do not touch.

BIBLIOGRAPHY

1. General Electric Company, "Effects of Electrical Shock", Installation and Service Engineering Department Manual, 1972.
2. Leonard, Milton, "The Clampdown on Electrical Hazards," Machine Design Magazine, January 9, 1975, pp. 20-24.
3. Mason, W. A., "Electrical Hazards in Underground Bituminous Coal Mines," MESA IR 1018.
4. Mining Enforcement & Safety Administration, Coal Mine Safety Electrical Inspection Manual for Underground Coal Mines, Surface Coal Mines, and Surface Work Areas of Underground Coal Mine, November 1973.
5. U. S. Code of Federal Regulations, Title 30 - Mineral Resources; Chapter 1 -- MESA, Department of the Interior, Part 75, Subparts F, G, H, I, J, and K, July 1, 1975, pp.371-394.
6. U. S. Code of Federal Regulations, Title 30 - Mineral Resources; Chapter 1 -- MESA, Department of the Interior, Part 77, Subparts F, G, H, I, and J, July 1, 1975, pp. 448-457.
7. U. S. Code of Federal Regulations, Title 30 - Chapter 1, Federal Metal and Nonmetallic Mine Safety Act, Parts 57.

APPENDIX

GLOSSARY OF TERMS

Arc -- Intense light and heat created when an electric circuit is opened.

Battery -- Source of D.C. electricity created from a chemical reaction.

Cable -- Insulated copper or aluminum wires contained in an insulated outer jacket used to conduct power to electric equipment.

Circuit breaker -- Device used to manually disconnect power from a circuit or automatically disconnect power under abnormal conditions.

Combustible -- Capable of burning. i.e. coal, methane, grease, wood, etc.

Conductor -- Copper or aluminum wires that carry electric current to electric equipment.

Current -- Movement of small particles (electrons) through electric conductors measured in amperes.

De-energize -- To disconnect an electrical circuit from its source of power.

Electrocution -- Death from an electric current flowing through the body.

Enclosure (electrical) -- A metallic box or frame that encloses electrical equipment or circuits.

Energized -- A circuit that has electric power connected to it.

Ground wire or frame ground wire -- A wire, connected to the metal frames of electric equipment on one end and the earth on the other, used to prevent electric shock.

Insulation -- Non-conducting material such as rubber or plastic used to cover electric conductors.

Qualified electrician -- An electrician, who through training and experience, has shown that he can perform electrical work safely and efficiently.

Resistance -- Opposition to electric current flow.
Shock (electrical) -- Sensation caused by an electric current flowing through the body.
Splice -- Mechanical joining of conductors that have been separated.
Switch -- Device that is used to disconnect power from an electric circuit.
Sulfuric acid -- Solution used in batteries to create electric power, which can severely burn human tissues.
Trailing cable -- Cable used to conduct power to mobile mining machines.
Trolley wire -- Bare copper conductor supported from the mine roof that supplies D.C. power to electric locomotives.
Trolley feeder wire -- Bare copper or aluminum conductor paralleling the trolley wire that supplies D.C. electric equipment.
Ventricular fibrillation -- A condition in which the heart ceases its normal pumping action and instead, feebly quivers.
Voltage -- Electrical pressure that forces a current to flow, measured in volts.

ABOUT THE AUTHORS

James E. Elswick

Mr. Elswick served as an instructor of Electrical Engineering for the Department of Labor, National Mine Health and Safety Academy. He was involved in the instruction of electrical systems to mine inspectors and industry personnel, both coal and metal/nonmetal. Mr. Elswick has a BS degree in Electrical Engineering from West Virginia Tech. He is a registered Professional Engineer, member of IEEE and Tau Beta Pi Association. He was formerly an Electrical Engineer for MSHA, Coal Mine Health and Safety and Appalachian Power Company.

Frank R. Schwamberger

Mr. Schwamberger is Chief, Division of Policy and Program Coordination for the Department of Labor in Arlington, Virginia. He is currently involved with mandated health and safety training requirements. He has a BS degree in Electrical Engineering from the University of Pittsburgh. He was formerly associated with the Consolidation Coal Company. Mr. Schwamberger is a member of the Mine Educators Association.

☆U.S.Government Printing Office: 1987--748-048/60019

SAFETY MANUALS

Accident Investigation
Accident Prevention
Coal Mine Maps
Coal Mine Roof and Rib Control
Coal Mining
Electrical Hazards
Fault Tree Analysis
Fire Safety
First Aid
Heat Stress in Mining
Industrial Hygiene for Healthier Miners
Job Safety Analysis
Laboratory Safety
Mine Escapeways
Mine Gases
Mine Ventilation
Permissibility - Electric Face Equipment
Personal Protective Equipment
The Radiation Hazard in Mining
Safety Tips for Underground Coal Mining
System Safety Engineering
Winter Alert